WORKSHOP ON

"THE ROLE OF RADAR IN THE ARNO PROJECT: RELATED PROBLEMS AND RESEARCH OPPORTUNITIES"

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RADAR SITE AND FIELD OF EXPERIMENTS

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Abstract

Some experimental activities are under definition to be developed with the dual linear polarization meteorological radar that will be used for the Arno Project. In this paper the main characteristics of the radar site are pointed out, which make it adequate for experiments of interest for hydrological modeling and forecasting studies.

Preliminary evaluations are made about the areas and measurement conditions that data collected by the Arno Project radar can usefully be analysed for. This is made with particular reference to those tests aiming at checking both the precision of radar rainfall estimates and their optimal integration with raingage measurements at ground, as well as at evaluating the exploitation of overall meteorological information provided by radar for hydrological applications.

Introduction

Within the experiments related to the Arno Project a meteorological radar POLAR 55C was supplied by IFA - CNR and its installation was initially planned on Monte Maggio, near the city of Siena. Due to some impediments set by the Environment Commission of the Siena province, this project had to be suspended and an alternative site had to be found, in order to carry out the planned experiments of the Arno Project.

This task was accomplished through an active cooperation between the University of Florence and the S.M.A. Company and the new radar site has been localized near Montagnana, about 15 km far from Florence (Fig. 1), in an area adjacent the Selesmar Company and owned by the S.M.A. Company itself. It can be said that the chosen site has got favourable logistic conditions and it guarantees the possibility of realizing an efficient meteorological radar station in a relatively short time, so as to carry out the opportune mesurement campaigns for an operative usage of the radar itself. Experiments through the radar operating in such a site are presently planned for two years, starting from 1991.

Analysis of radar visibility

Radar's ability to detect rainfall has proved to be quite valuable in the field of meteorology, as meteorological radars allow for a real-time observation of rainfall fields, through a continouos three-dimensional space scanning of precipitation. Nevertheless, radar rainfall rate measurements may be affected by significant errors, some of which are related to critical orography and morphology of the ground area within the radar coverage. In this condition, especially when working at low elevation angles, the meteorologcal radar enlightens the ground and the obstacles on it, and this fact produces ground clutter with a strenght comparable to that of precipitation return. Consequently, radar rainfall measurements can be significantly affected by ground clutter in some coverage areas, and radar visibility can also be limited by prominent ground obstacles near the radar site.

In order to verify radar visibility in the new site, a simulation model has been used so as to take into account natural ground clutter and propagation blockage effects [1]. Such a model is based on a digital terrain map of Tuscan region and allows to produce radar coverage maps for set elevation angles, radar coverage maps for set mininum heights and ground clutter maps. The effect of near obstacles has also been taken into account, their azimuth and elevation having been measured by a theodolite (Fig. 2).

In Figs. 3 and 4 some radar coverage maps are shown, for minimum height of 1000 and 1500 m, and of 2000 and 3000 respectively. It is easy to observe that even for minimum heigth of 1000 m a sufficiently good coverage of a great part of the Arno basin is obtained, apart from the upper basin where the effects of the Pratomagno Mountain are quite strong and an area in the south of the radar site, where the effects of near obstacles can be detected. Radar visibility appears to be good especially towards the west, which is the direction storm events arrives from, so that the meteorological radar can be a very useful instrument also for nowcasting activities. In Fig. 5 a simulated ground clutter map is shown, where the ground echo from Casentino and Upper Valdarno is pointed out.

Radar site arrangements

The chosen radar site is approximately 760 square metres large and it is located near the Selesmar Company factory, as shown in Fig. 6. In order to realize a completely independent area, a separeted access was planned and the whole site has been penned so as to prevent damages due to strangers' entrance.

The POLAR 55C antenna is placed on a metallic framing tower whose foundations are built with four isolated footings. The tower is about 10 m high, in order to reduce the blockage effects due to near obstacles.

Three equipped shelters are dedicated to the correct management of the radar plant, two of them are installed under the antenna tower, while the third one is located nearby. One of the shelter is dedicated to the power control and regulation panels, while another one contains the control and elaboration services, such as the radar console, a personal computer, an optical disk where data will be stored and so on. Finally, a generator set finds place in the third shelter together with the generator set fuel tank and a drinkable water tank, so as a temporary independence is assured. The three shelters are placed on superelevated curbs, in order to avoid direct contact with the ground.

As far as the radar apparatus is concerned, improvements are nearly completed by the S.M.A. Company, especially on the signal processing subsystem and the antenna control subsystem.

Civil works at the radar site are still in progress and should be concluded within 1990, while radar initial operations are planned to start in January 1991.

Punctual ground sensors

In order to realise a high temporal resolution digital data base and to support the spatial rainfall fields measurements obtained by the meteorological radar, a punctual sensors network is going to be installed and a first experimental node was located at the School of Engineering in Florence.

The measured meteorological variables have been chosen by significance criteria in the study of precipitation phenomena, so the measurements of temperature and relative air humidity, of wind direction and velocity and of direct sun radiation are carried out together with rainfall measurements.

A disdrometer also is present for the drop size distribution measurements; such a system is kept independent from the rest of the sensors as its functioning is limited to short experimental periods.

The architecture of the whole set is thus organised in three tightly connected levels:

a) the sensors system;

b) the signal processing and local storage memory system;

c) the interface with the local Ethernet network.

Apart from the disdrometric system, a configurable C.A.E. station was adopted to realise the above mentioned architecture [2]. The station is composed of a set of electromagnetic transduction sensors (system a) interfaced through short range dedicated lines with a local exchange containing part b and c. Such an exchange performs the following operations:

- signal acquisition from each sensor and A/D conversion through the opportune dedicated interfaces;
- data pre-elaboration (averages, integrations etc.) and storage on an extractable EEPROM unit;
- radio-modem-computer communication interface management through predefined protocols.

The station is equipped with a battery which allows the functioning in absence of line voltage, while the connection with the local Ethernet network is realised by a serial line.

As far as the disdrometer is concerned, as said before it measures raindrop size distribution continuously and automatically. The instrument transforms the vertical momentum of an impacting raindrop into an electric pulse, whose amplitude is a function of the drop diameter. A conventional pulse height analysis yields the size distribution of the raindrops [3].

Radar experiments

Although the chosen site doesn't permit a full coverage of the whole Arno basin and it can't be considered optimal to realise a complete system for flash flood forecasting, its characteristics allows for measurement campaigns to evaluate the multiple problems connected with radar rainfall rate estimates.

In particular the following aspects will be taken into account as soon as the meteorological radar becomes operative:

- space-time evolution analysis of storm events over the Arno basin;
- storm tracking techniques and short time prediction techniques;
- generation of composite products from radar and satellite images;
- calibration techniques by using raingages and disdrometers;
- application and evaluation of partial screening techniques;
- clutter removal techniques in presence of rainfall;
- verification of the attenuation correction in C-band.

Hydrological experiments

The use of the meteorological radar, together with some punctual sensors like those previously described, will allow to carry out some hydrological studies in certain areas in the Arno basin. In Fig. 7 the radar coverage map at minimum height 1500 m over the whole basin is shown and areas of hydrological interest are outlined.

In particular, as radar rainfall rate estimates represent a good input for hydrological distributed models, the Sieve basin, which is quite well covered by the radar, will be used for testing and fitting of such models [4] with special reference on flash flood forecasting, due to the high risk conditions on which this basin is subjected. On the other hand, the Bisenzio basin may represent a good test area for first hydrological elaborations, as it is a very compact basin with a simple geological structure which allows to take into account soil parameters with not too much difficulty.

As far as the Sesto Fiorentino plain is concerned, its position and dimension make it an ideal area for all the calibration operations with raingages and disdrometers, and some meteorological stations like the one previously described will be presently installed in such an area.

Finally, a cooperation between the University of Florence and the Chianti Classico Consortium will allow to carry out some interesting experiments in the Chianti Classico area, even if the radar coverage is not complete due to the effects of the nearest obstacles. In particular, analysis of erosive phenomena and agrometeorological studies on vine and olive cultivation will be developed, also utilizing the Consortium raingage network as a further calibration instrument.

Conclusions

In the present work a summary of the status of the installation operations regarding the POLAR 55C weather radar was presented, within the researches developed for the Arno Project. The characteristics of the chosen radar site were briefly pointed out, which can allow for the starting of both radar rainfall rate measurement experiments and the evaluation of analysis and correction techniques for the various types of error affecting the measure itself.

Within the Arno basin four areas were finally outlined, where several hydrological analysis techniques will be experimented, also using data from punctual sensors stations located in the basin which will constitute a calibration and integration system for the meteorological radar.

References

[1] Freni A., D. Giuli, M. Fossi, "Simulation models for meteorological radar siting", Alta Frequenza, vol. LVIII, n. 4, July-August 1989.

[2] "Acquisition and management system of hydrometeorological data. C.A.E. - 200 Technical description", CAE s.r.l., Jan. 1988 (in Italian).

[3] "Analyser ADA-90. Instruction manual", DISDROMET Ltd, 1988.

[4] Becchi I., E. Caporali, G. Federici, E. Palmisano, "A distributed model for the Arno basin: hydrological analysis of Sieve watershed", Acqua-Aria, n. 10, 1989 (in Italian).

FIGURE CAPTIONS

Fig. 1 Geographical framing of the radar site.

Fig. 2 Azimuth and elevation of near obstacles as measured by a theodolite.

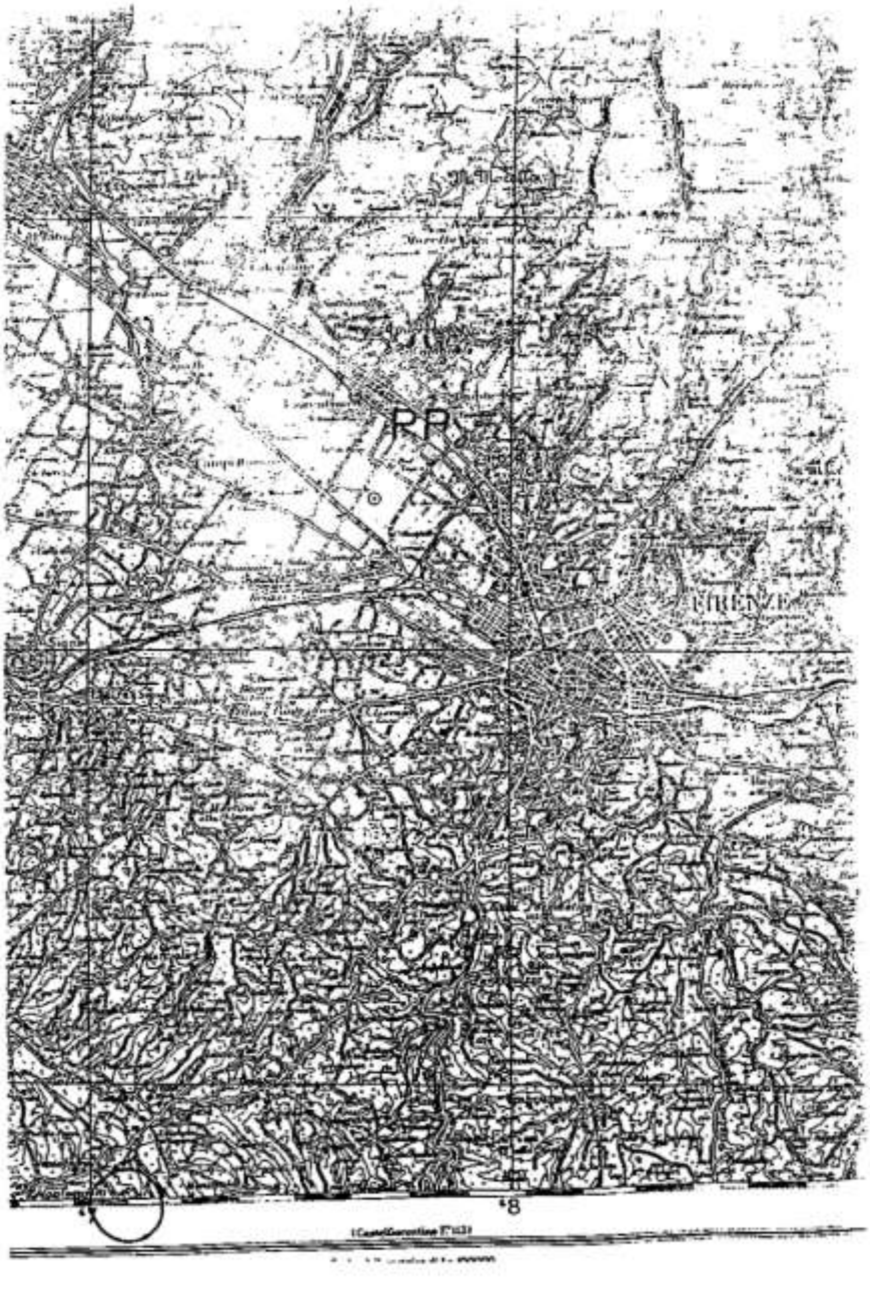
Fig. 3 Radar coverage map for minimum height of 1000 m (solid line) and of 1500 m (dashed line).

Fig. 4 Radar coverage map for minimum height of 2000 m (solid line) and of 3000 m (dashed line).

Fig. 5 Ground clutter map.

Fig. 6 Radar site scheme.

Fig. 7 Arno basin radar coverage map at 1500 m with areas of hydrological interest outlined.



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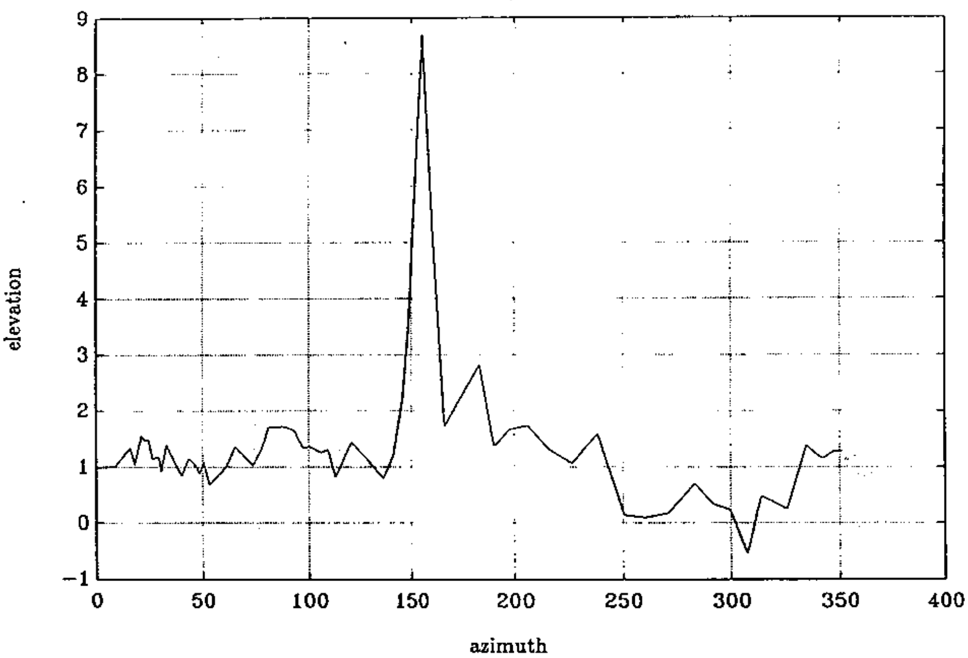


Fig. 2 Azimuth and elevation of near obstacles as measured by a theodolite.

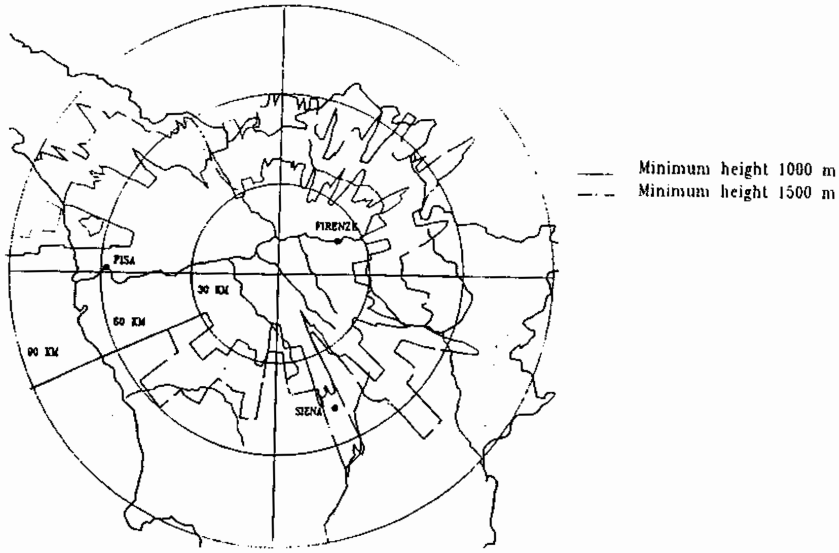


Fig. 3 Radar coverage map for minimum height of 1000 m (solid line) and of 1500 m (dashed line).

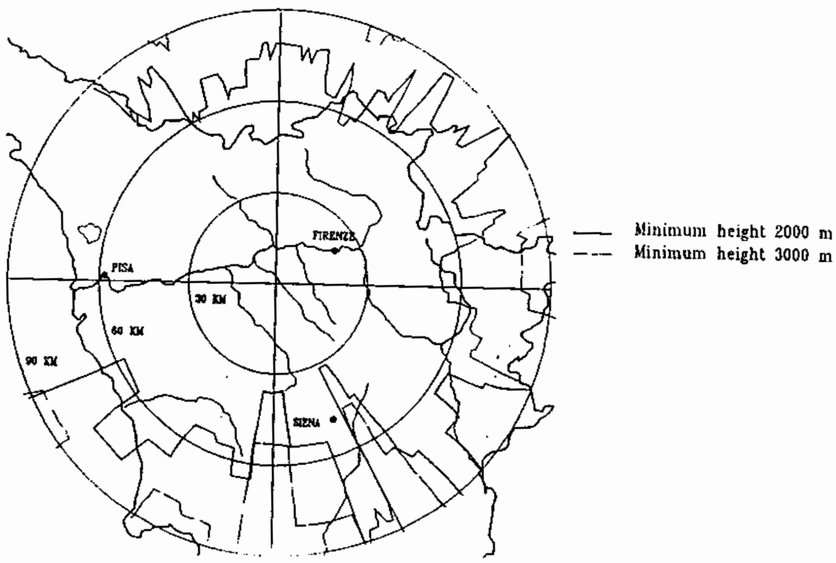


Fig. 4 Radar coverage map for minimum height of 2000 m (solid line) and of 3000 m (dashed line).

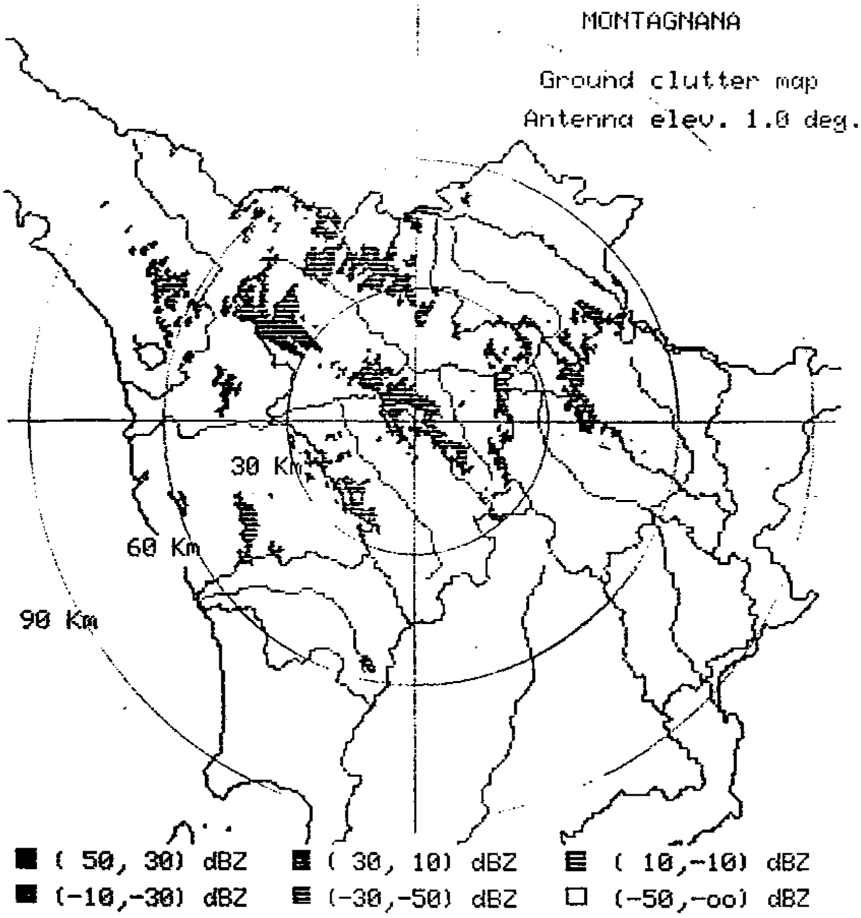
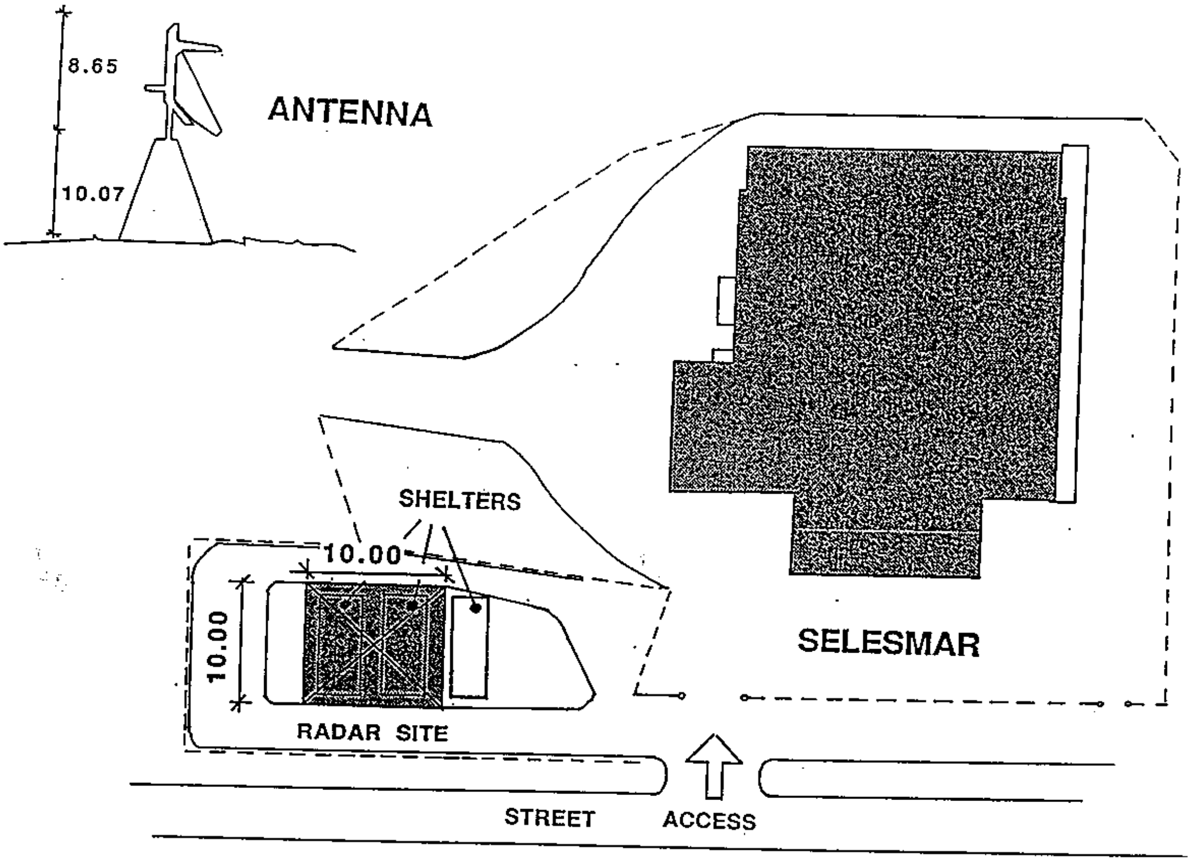


Fig. 5 Ground clutter map.



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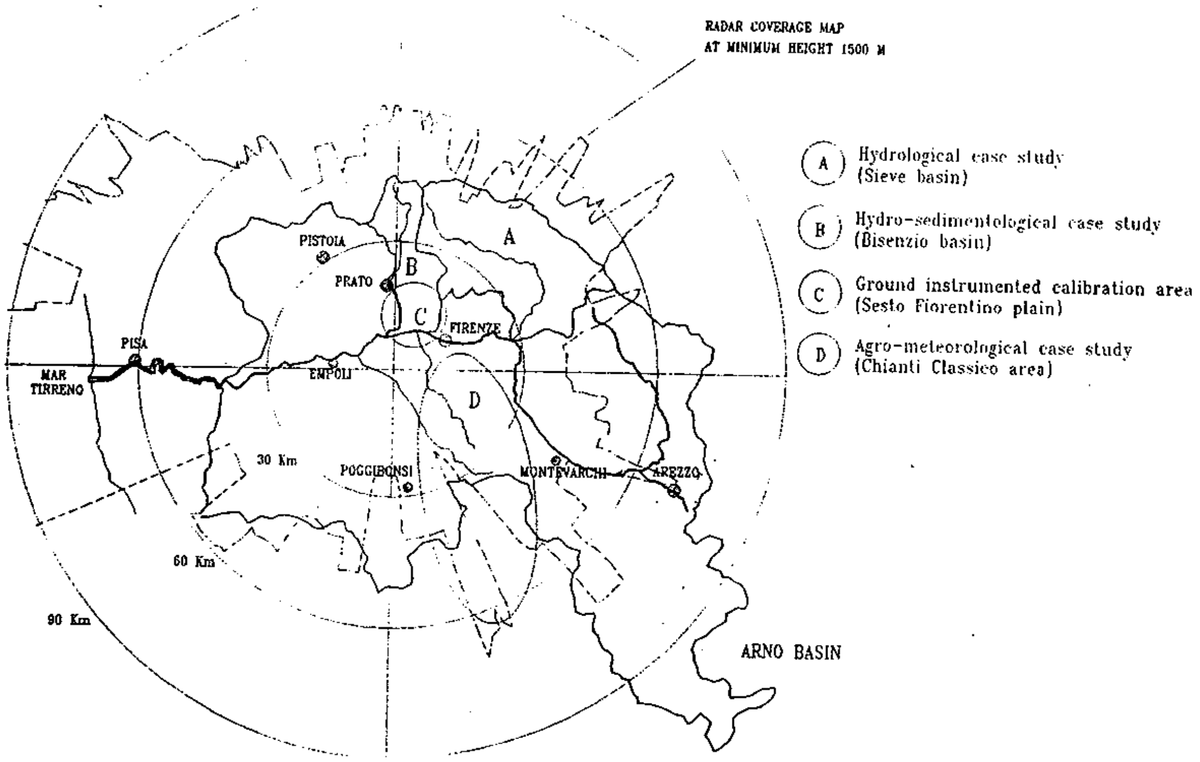

Fig. 7 Arno basin radar coverage map at 1500 m
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